

motor ideas), the sensory regions being looked upon as the organic seat of ideas derived from sensory impressions. An explanation is attempted of the phenomena of aphasia, and the relation of the memory of words to the ideas they represent.

The theory that a certain action, excited by stimulation of a certain centre, is the result of a mental conception is considered and disputed. From the complexity of mental phenomena, and the participation in them of both motor and sensory substrata, any system of localization of mental faculties which does not take both factors into account must be radically false. A scientific phrenology is regarded as possible.

The paper concludes with a short consideration of the relation of the basal ganglia to the hemispheres. The view is adopted that they constitute a subvoluntary or automatic sensori-motor mechanism.

March 12, 1874.

JOSEPH DALTON HOOKER, C.B., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following Papers were read :—

- I. “Contributions to the Developmental History of the Mollusca. Sections I., II., III., IV.” By E. RAY LANKESTER, M.A., Fellow of Exeter College, Oxford. Communicated by G. ROLLESTON, M.D., F.R.S., Linacre Professor of Anatomy and Physiology in the University of Oxford. Received January 19, 1874.

(Abstract.)

Section I. *The ovarian Egg and early development of Loligo.*

The points of greatest interest to which the author draws attention in the present memoir are :—

1. The explanation of the basketwork structure of the surface of the ovarian egg by the plication of the inner egg-capsule.
2. The increase of the yolk by the inception of cells proliferated from the inner egg-capsule.
3. The homogeneous condition of the egg at fertilization.
4. The limitation of yolk-cleavage to the cleavage-patch.
5. The occurrence of independently formed corpuscles (the autoplasts) which take part in the formation of the blastoderm.
6. The primitive eye-chamber, formed by the rising up of an oval wall and its growing together so as to form a roof to the chamber.
7. The origin of the otocysts by invagination.
8. The rhythmic contractility of a part of the wall of the yolk-sac.

9. The disappearance of the primitive mouth, and the development of a secondary mouth.

10. The development of a pair of large nerve-ganglia by invagination of the epiblast immediately below the primitive eye-chambers.

General Considerations relative to the Observations contained in Sections II., III., IV. (containing the developmental histories of Pisidium, Aplysia, Tergipes, Polycera, and Neritina).

In these observations the author points out briefly their bearing on two matters of theoretical importance, viz. (1) the origin and significance of what has been called the *Gastrula*-phase of development, and (2) the homologies or homogenies (as the author prefers to say) of the shells, ligaments, and internal pens of the Mollusca. More facts have to be sought out and brought to bear on these questions; but the author, while occupied in that further search, indicates the anticipations which must guide and stimulate it. Before doing so he mentions that there are a variety of other matters of interest in the facts recorded in the paper which cannot yet be brought into any theoretical structure, but which are not on that account kept back, as they will probably be of some service in their isolated condition.

Kowalevsky was the first to describe, in a precise manner, the formation of the foundations of the alimentary tract in a developing embryo, by invagination of the wall of a simple primitive blastosphere, or hollow ball of embryonic cleavage-corpuscles. He detected this mode of development in *Amphioxus*, and subsequently in *Ascidia*. By later researches he was able to indicate the same mode of development in certain Vermes (*Sagitta*, *Euaxes*, *Lumbricus*); and he mentioned incidentally that he had observed a similar development in the Heteropodous mollusk *Atalanta*. At that time the author was studying the development of *Pisidium* and *Limax*, and obtained evidence of the invagination of the primitive blastosphere in those two widely separated mollusks. Subsequently at Naples he found the same process occurring in Nudibranchs. The probable identity of this process of invagination with that so well known in the Batrachians, especially through Stricker's admirable work on the subject, became clear, to those occupied with embryological studies, from the facts established by Kowalevsky; and the "anus of Rusconi" could now be recognized in the "orifice of invagination" present in members of the three large groups of Vermes, Mollusca, and Vertebrata.

The embryonic form produced by this invagination-process is a simple sac composed of an ectoderm and endoderm, with an orifice connecting the exterior with the cavity lined by the endoderm. It, in short, presents the typical structure of the simplest Cœlenterata, and corresponds exactly with the so-called *Planula* of the polyps and corals. Hence we are tempted to see in this primitive invagination-form the representative of the Cœlenterate phase of development of the whole animal kingdom.

In a paper published in May 1873*, containing the substance of lectures delivered in the preceding October, the author discussed this notion at some length, and other points connected with the attempt to work out the correspondences of the embryonal cell-layers of the various groups of the animal kingdom. At the end of the year 1872, Professor Hæckel's splendid Monograph of the Calcareous Sponges appeared, in which the same questions are methodically discussed. The name *Gastrula* is given by Professor Hæckel to the embryonic form which the author proposed to designate by the old name *Planula*; and the multicellular blastosphere, from which the *Gastrula* is developed, which the author had proposed to speak of as a *Polyplast*, he well christens the *Morula*. Professor Hæckel was able to show in his monograph that the Calcareous Sponges exhibit a beautifully definite *Gastrula*-larva, which swims freely by means of cilia. Lieberkühn, Miklucho-Maclay, and Oscar Schmidt had previously shown that certain sponges exhibit such an embryonic form; but Professor Hæckel described it in many cases, and showed fully its mode of development and structure.

This brings us to an important point in what Hæckel calls the "Gastræa theory"†. The *Gastrula* form of the Calcareous Sponges is *not* formed by invagination, but without any opening in the blastosphere making its appearance; the cells constituting its walls divide into an endoderm and an ectoderm; then, and not until then, an orifice is formed from the central cavity to the exterior by a breaking through at one pole. Careful accounts of the development of Cœlenterata, with a view to determine the mode of development of the *Planula* or *Gastrula* form in regard to the question of invagination, are not to hand in a large number of cases. But, on the one hand, we have Kowalevsky's account of the development of *Pelagia* and *Actinia*, in which the formation of a *Gastrula* by invagination is described, as in the cases already cited among Vermes, Mollusca, and Vertebrata; on the other hand, we have Allman's observations on the Hydroids, Schultze's on *Cordylophora*, Kleinenberg's on *Hydra*, Hæckel's on the Siphonophora, and Hermann Foll's on the Geryonidæ, in which the ectoderm and endoderm of the embryo (which is at first a *Planula* without mouth, then a *Gastrula* with a mouth) are stated to arise from the splitting or "delamination" of a single original series of cells forming the wall of the blastosphere. Hermann Foll's observations are of especial value, since he shows most carefully how, from the earliest period, even when the egg is unicellular, its central part has the character of the endodermal cells, its peripheral part that of the ectodermal cells.

The question now arises, can the *Gastrulae* which arise by invagination be regarded as equivalent to those which arise by internal segregation of an endoderm from an ectoderm? and if so, which is the typical

* Annals and Mag. Nat. Hist. 1873, xi. p. 321.

† His most recent views on this matter are contained in a pamphlet dated June 7, 1873, 'Die Gastræa-Theorie.'

or ancestral mode of development, and what relation has the orifice of invagination in the one case to the mouth which, later, breaks its way through in the other?

It is not within the scope of the present memoir to discuss these questions at length; but the author is of opinion that we must regard the *Gastrula*-sac with its endoderm and ectoderm as strictly equivalent (homogenous, to use another expression) in the two sets of cases. One of the two methods is the typical or ancestral method of development, and the departure from it in the other cases is due to some disturbing condition. He believes that we shall be able to make out that disturbing element in the condition of the egg itself as laid, in the presence in that egg of a greater or less amount of the adventitious nutritive material which Edouard van Beneden calls "deutoplasm." This and certain relations of bulk in the early developed organs of the various embryos considered, determine the development either by invagination or by delamination. The relation of bulk to the process of invagination may be illustrated from a fact established in the preceding communications. In *Loligo* the large otocysts develop, each, by a well-marked invagination of the epiblast, forming a deep pit which becomes the cavity of the cyst. In *Aplysia* the smaller otocysts develop, each, by a simple vacuolation of the epiblast without invagination. In *Loligo* the chief nerve-ganglia develop by invagination of the epiblast, in *Aplysia* by simple thickening. Again, in Vertebrata the nerve-cord develops by a long invagination of the epiblast; in *Tubifex* and *Lumbricus* the corresponding nerve-cord develops by a thickening of the epiblast without any groove and canal of invagination.

The bulkier structures in these cases are seen to develop by invagination, the smaller by direct segregation. Invagination therefore acts as an economy of material, a hollow mass being produced instead of a solid mass of the same extent.

That the presence of a quantity of deutoplasmic matter, or of a partially assimilated mass of such matter, in the original egg is not accompanied by well-marked invagination of the blastosphere, while the absence of much deutoplasm is the invariable characteristic of eggs which develop a *Gastrula* by invagination, is shown by a comparison of *Aplysia* and *Loligo* with *Pisidium* and *Limax*, and of the Bird with the Batrachian. In some cases, such as Selenka has characterized by the term "epiboly," it seems that the enclosure of the large yolk-mass by the overgrowth of cleavage-cells may be held as equivalent to the invagination of the large yolk-cells by "emboly;" and the intermediate character which the development of *Euaxes* and *Lumbricus* present in this respect, as described by Kowalevsky, tends very strongly to establish a transition.

But the mode of development of the *Gastrula* of Geryonidæ, described with so much minuteness by Foll, which is obviously the same as that of the *Gastrulæ* of Spongiadæ and most Hydroids, is clearly no masked case

of invagination. There is no question of "epiboly" here, but a direct and simple splitting of one cell into two; so that what was a sac formed by a layer of cells one deep, becomes a sac formed by a layer of cells two deep, or of two layers each one deep.

It is yet a question for much further inquiry as to how this mode of forming a double-walled *Gastrula* can be derived from, or harmonized with, the formation of *Gastrulae* by the embolic or epibolic forms of invagination.

It would certainly seem at present that the orifice of invagination of the invaginate *Gastrula* must *not* be regarded as the equivalent of the later erupting *mouth* of the segregate *Gastrula**, which is the true permanent mouth of the Sponge or Coelenterate. In no case is the orifice of invagination of the invaginate *Gastrula* known to persist under any form; it appears solely to effect the invagination, and when that is effected vanishes.

Enough has been said to show the importance of observations relating to the *Gastrula*-phase of development. In the paper well-marked invaginate *Gastrulae* are described from:—

1. *Pisidium* (Lamellibranch).
2. *Tergipes* (Nudibranch).
3. *Polycera* (Nudibranch).
4. *Limax* (Pulmonate).
5. *Limnæus* (Pulmonate).

In addition to these cases of the development of invaginate *Gastrulae* among Mollusca, the examination of the very beautiful figures in the papers of Lovén on molluscan development leaves no doubt that he has observed invaginate *Gastrulae* in the following cases, but has not understood their structure:—

6. *Cardium* (Lamellibranch).
7. *Crenella* (Lamellibranch).

Similarly, Karl Vogt's observations on *Actæon* indicate the same state of things as the author has pointed out in *Polycera*; and hence we may add:—

8. *Actæon* (Nudibranch),

and, finally, from Kowalevsky's statement, though not accompanied by figure or description,

9. *Atalanta* (Heteropod).

The second matter of theoretical interest (namely, the early features in the development of the shell) has not been previously discussed, since the structures described in the paper as shell-patch, shell-groove, and shell-plug were unknown.

If, as seems justifiable, the Cephalopoda are to be regarded as more

* In his paper in the 'Annals' for May 1873 the author has inclined to the view that it *may* be so regarded.

nearly representing the molluscan type than do the other classes, or, in other words, more closely resemble the ancestral forms than they do, we might look, in the course of the development of the less typical Mollusca, for some indication of a representative of the internal pen of the higher Cephalopoda. We might expect to find some indication of the connexion between this and the calcareous shell of other forms; in fact the original shell of all Mollusca should be an internal one, or bear indications of a possible development into that condition.

In *Pisidium*, in *Aplysia*, and in *Neritina* the author has submitted evidence of the existence of a specially differentiated patch of epidermic cells at the aboral pole, which develops a deep furrow, groove, or pit in its centre almost amounting to a sac-like cavity opening to the exterior. The first (chitinous) rudiment of the shell appears as a disk on the surface of this gland; but also, in some cases, the cavity or groove is filled by a chitinous plug.

Let the walls of the sac close and the activity of its lining cells continue, and we have the necessary conditions for the growth of such a "pen" as that of the Decapodous Cephalopods.

At present the details of the development of the "pen" in the Cephalopoda are not fully known; but the author has evidence that it is formed in an enclosed sac-like diverticulum of the epidermis, but he has not yet ascertained the earliest condition of this sac. The history of its development becomes surrounded with additional interest in relation to the shell-gland of the other Mollusca.

The position of the groove of the shell-gland in *Pisidium* suggests a possible connexion of its chitinous plug with the ligament, which it will be worth inquiring into in other developmental histories of Lamellibranchs.

The internal shells of other Mollusca besides the cuttlefish are certainly not in some cases (e. g. *Aplysia*) primitively internal, but become enclosed by overspreading folds of the mantle. But in the case of *Limax* and its allies, it is possible, though the matter requires renewed investigation, that the shell is a primitively internal one representing the shell-plug.

There is yet one more possible connexion of this shell-gland and plug: this is the chitinous secretion by which *Terebratulina* and its allies fix themselves to rocks &c. The position of the peduncle exactly corresponds to that of the shell-gland; and an examination of Professor Morse's recently published account of the development of *Terebratulina* leaves little doubt that at the pole of attachment, which very early develops its function and fixes the embryo, an in-pushing occurs, and a kind of shallow gland is formed which gives rise to the horny cement. The author's own observations on the development of *Terebratulina vitrea* do not extend to so early a period as this.

It is perhaps scarcely necessary, in conclusion, to point out the close resemblance of shell-gland and plug to the byssal gland and its secretion.

They are closely similar structures; but there does not appear to be any reason for considering them "serial homologues," or more closely related than are, say, the hairs on the head of a man with the hairs on his chest.

II. "On a New Deep-sea Thermometer." By HENRY NEGRETTI and JOSEPH WARREN ZAMBRA. Communicated by Dr. CARPENTER, F.R.S. Received March 5, 1874.

The Fellows of the Royal Society are perfectly aware of the assistance afforded by Her Majesty's Government (at the request of the Royal Society) for the purpose of deep-sea investigations, and have been made acquainted with their results by the Reports of those investigations published in the 'Proceedings of the Royal Society' and by the interesting work of Professor Wyville Thomson. Among other subjects, that of the temperature of the sea at various depths, and on the bottom itself, is of the greatest importance. The Fellows are also aware that for this purpose a peculiar thermometer was and is used, having its bulb protected by an outer bulb or casing, in order that its indications may not be vitiated by the pressure of the water at various depths, that pressure being about 1 ton per square inch to every 800 fathoms. This thermometer, as regards the protection of the bulb and its non-liability to be affected by pressure, is all that can be desired; but unfortunately the only thermometer available for the purpose of registering temperature and bringing those indications to the surface is that which is commonly known as the Six's thermometer—an instrument acting by means of alcohol and mercury, and having movable indices with delicate springs of human hair tied to them. This form of instrument registers both maximum and minimum temperatures, and as an ordinary out-door thermometer it is very useful; but it is unsatisfactory for scientific purposes, and for the object which it is now used (*viz.* the determination of deep-sea temperatures) it leaves much to be desired. Thus the alcohol and mercury are liable to get mixed in travelling, or even by merely holding the instrument in a horizontal position; the indices also are liable either to slip if too free, or to stick if too tight. A sudden jerk or concussion will also cause the instrument to give erroneous readings by lowering the indices, if the blow be downwards, or by raising them, if the blow be upwards. Besides these drawbacks, the Six's thermometer causes the observer additional anxiety on the score of inaccuracy; for, although we get a *minimum* temperature, we are by no means sure of the point where this minimum lies. Thus Professor Wyville Thomson says ('Depths of the Sea,' p. 139):—"The determination of temperature has hitherto rested chiefly upon the registration of minimum thermometers. It is obvious that the temperature registered